

# Injecting Gas Oxidants to Oxidize Hg<sup>0</sup> for Control of Mercury Emission from Coal-fired Power Plants

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## Introduction

Mercury in flue gas of coal-fired power plants is primarily gas-phase elemental (Hg<sup>0</sup>) and oxidized forms. It has been demonstrated that wet SO<sub>2</sub> scrubbers can remove oxidized mercury quite efficiently but have little effect on Hg<sup>0</sup>. This study aims at finding a gas oxidant for injection into the duct to oxidize Hg<sup>0</sup> in flue gas to facilitate a simultaneous removal of mercury and SO<sub>2</sub> in wet scrubbers.

The challenges to overcome are: 1. Hg<sup>0</sup> concentration is several orders of magnitude smaller than other reducing gases, SO<sub>2</sub> and NO, also present in flue gas, and 2. flue gas residence time prior to wet SO<sub>2</sub> scrubbers is short, on the order of seconds. Therefore, effective oxidants must be selective and rapid in Hg<sup>0</sup> oxidation. Also, the oxidants must be low cost, and environmental benign.

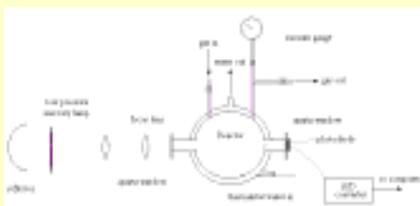
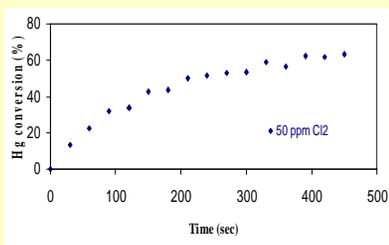


Fig. 1. Schematic of Apparatus



## Experimental

Fig. 1 is the schematic of the apparatus. The reaction was performed in a 330 ml Pyrex double jacket thermostat cell equipped with two quartz windows having an optical path of 15 cm. The Hg<sup>0</sup> concentration was monitored at 253.7 nm continuously by cold vapor atomic absorption spectroscopy during the course of the reaction.

Fig. 2 shows the reaction of Hg<sup>0</sup> with Cl<sub>2</sub> gas. The rate constant determined was  $2.6 \times 10^{-18}$  cm<sup>3</sup>/molecule-sec at 294K. The observed half-life of Hg<sup>0</sup> with 50 ppm of Cl<sub>2</sub> was 250 sec. Therefore, the oxidation of Hg<sup>0</sup> by Cl<sub>2</sub> is ineffective.

Fig. 2. Oxidation of Hg<sup>0</sup> by Cl<sub>2</sub>

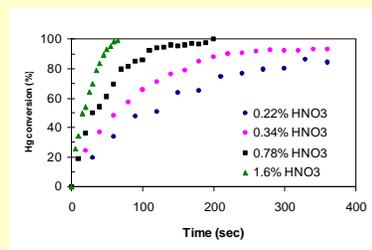


Fig. 3. Oxidation of Hg<sup>0</sup> by HNO<sub>3</sub>

Fig. 3 shows the reaction of Hg<sup>0</sup> with HNO<sub>3</sub> vapor. The rate constant determined was  $1.2 \times 10^{-19}$  cm<sup>3</sup>/molecule-sec at 294K. The observed half-life of Hg<sup>0</sup> with 1.6 % HNO<sub>3</sub> was 12 sec. Therefore, the oxidation of Hg<sup>0</sup> by HNO<sub>3</sub> is not practical.

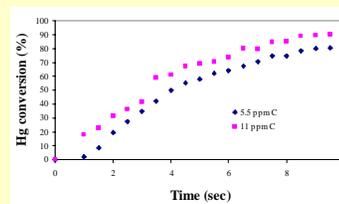


Fig. 4. The Oxidation of Hg<sup>0</sup> by Oxidant C

Fig. 4 shows the reaction of Hg<sup>0</sup> with oxidant "C". The rate constant determined was  $7.3 \times 10^{-16}$  cm<sup>3</sup>/molecule-sec at 294K. The observed half-life of Hg<sup>0</sup> with 11 ppm of "C" was 3 sec.

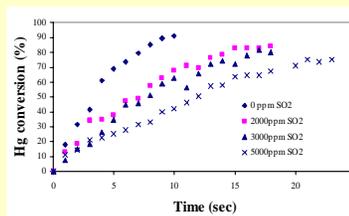


Fig. 5. Effect of SO<sub>2</sub> on the Oxidation of Hg<sup>0</sup> by C

Fig. 5 shows that SO<sub>2</sub> inhibited the oxidation of Hg<sup>0</sup> by "C". The apparent rate constant decreased to  $3.2 \times 10^{-16}$  cm<sup>3</sup>/molecule-sec at 294K. The half-life of Hg<sup>0</sup> increased to 7.2 sec in the presence of 2,000ppm SO<sub>2</sub> using 11 ppm of "C".

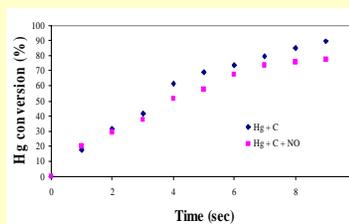


Fig. 6. Effect of NO on the Oxidation of Hg<sup>0</sup> by "C"

Fig. 6 shows that NO slightly inhibited the oxidation rate of Hg<sup>0</sup> by oxidant "C". The apparent rate constant decreased to  $6.2 \times 10^{-16}$  cm<sup>3</sup>/molecule-sec with 200 ppm NO at 294K. The half-life of Hg<sup>0</sup> increased to 4.6 sec in the presence of 2,000 ppmSO<sub>2</sub> using 11 ppm of "C".

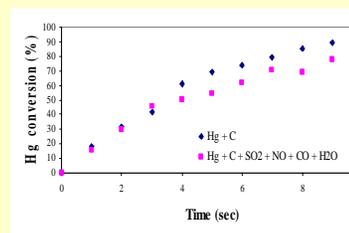


Fig. 7. The Oxidation of Hg<sup>0</sup> in Simulated Flue Gas

Fig. 7 shows the oxidation of Hg<sup>0</sup> by "C" in a simulated flue gas containing 3,000 ppm SO<sub>2</sub>, 200ppm NO, 40 ppm CO, and 27 ppm H<sub>2</sub>O. The apparent rate constant decreased to  $6.2 \times 10^{-16}$  cm<sup>3</sup>/molecule-sec at 294K. The half-life of Hg<sup>0</sup> increased to 4.6 sec using 11 ppm of "C".

## Conclusion

From the gas phase kinetic studies, we have found that Cl<sub>2</sub> and HNO<sub>3</sub> are ineffective for the oxidation of Hg<sup>0</sup> because the oxidation rates are too slow. The oxidant "C" has a large rate constant for the oxidation of Hg<sup>0</sup>. Although the rates decreased in the presence of SO<sub>2</sub> and NO, the net reaction rates appear to be large enough to convert a significant fraction of Hg<sup>0</sup> to the oxidized form within a short residence time of flue gas prior to wet SO<sub>2</sub> scrubbers.